the biofilm expressed genes involved in ComX production, and a small fraction of the population responded to ComX by producing surfactin. Furthermore, expression of the matrix protein operon was observed only in a subpopulation of cells. Importantly, however, surfactin-producing and matrix-producing cells were found as distinct populations, an observation that was confirmed by direct microscopy. Thus, Lopez *et al.* [1] concluded that surfactin producers are not capable of responding to the surfactin that they themselves generate and thereby provided a plausible explanation for the source of heterogeneity observed in the production of matrix.

As matrix producers do not become surfactin producers, the authors explored the possibility that the extracellular matrix physically prevents ComX action on the matrix producers. Lopez *et al.* [1] used different genetic backgrounds to manipulate the synthesis of the extracellular matrix and found that the levels of a ComX reporter were increased in the absence of extracellular matrix. They suggested that the matrix interferes with the ability of ComX to activate ComP, a kinase that phosphorylates a transcription factor required for surfactin production. They tested this interpretation using mutants lacking SinR, a repressor of matrix gene expression, which constitutively produce matrix. As expected, these cells did not produce surfactin, but they did produce functionally active ComX, as cleverly assayed using a heterologous strain that reports ComX activity but cannot synthesize ComX. Therefore, the defect in surfactin signaling does not lie in an inability to make ComX, but, consistent with the hypothesis, the matrix must somehow interfere with the ability of ComX to activate ComP and prevent the production of surfactin in matrix producers.

Thus, Lopez *et al.* [1] demonstrate that distinct populations of cells co-exist during *B. subtilis* biofilm formation, resulting in the formation of multicellular communities composed of genetically identical cells that are signal producers, signal responders or neither (Figure 1E). Surfactin-producing cells may become cells capable of genetic competence, whereas the matrix producers ultimately differentiate to become dormant spores. How these fates are determined by their prior developmental state remains unknown. In addition, an important question is how surfactin producers develop immunity to surfactin. The authors speculate that ComS, a protein produced by all surfactin-producing cells, may indirectly inactivate the transcription factor Spo0A that is required for the response to surfactin.

Cell–cell communication is central to a variety of developmental processes in bacteria. This signaling can be either between species or within species or between organisms that are in close proximity or between organisms that are in communities in which the signal-generating cell may be distant from the receiving cell. Further research will undoubtedly illuminate how these signaling events lead to genome-wide alterations in expression and provide genetically identical bacteria with the capability to exhibit individual phenotypic and communal properties.

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Visual Perception: Larger Is Faster

A recent study has shown that neurons in the inferior temporal cortex of the macaque monkey brain show earlier selectivity to global and large shapes than to local and small ones, which may underlie the faster behavioral responses to global aspects of a scene.

Rufin Vogels

A visual scene, for example of a forest, can be conceptualized as having different hierarchical levels of structure: from the global configuration, the forest, to its local elements, the trees. The results of decades of research suggest that humans analyse the global aspect of a visual scene before the local elements — the forest before its trees [1,2]. This issue has been investigated using, for example, Navon stimuli, named after their inventor David Navon [3]: these hierarchical stimuli consist of a global shape that is defined by the configuration of smaller, local shapes. The shapes of the global configuration and local elements can be manipulated independently (Figure 1), allowing the researchers to assess the degree to which the behavior of the subject is

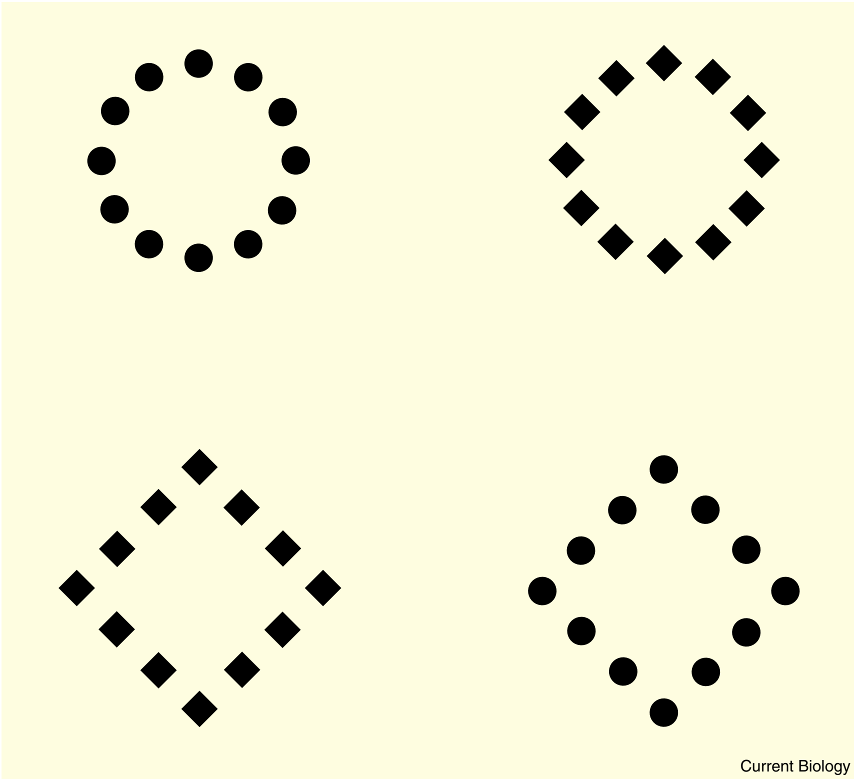

Figure 1. Navon or hierarchical stimuli used to investigate global and local shape analysis.
Note the orthogonal manipulation of local and global shape: the same global shape configuration (for example, a diamond) is defined by different local shapes (squares or diamonds). (Adapted with permission from [10].)

determined by the shape of the global configuration *versus* the shapes of its local constituents. Two effects have been documented in the studies using Navon stimuli: first, subjects respond faster to the global shape than to its local constituents, called the global-advantage effect; the second, more variable effect is that responses to the global shape are little affected by the local shape, while those to the local shape are slowed when local and global shape are incongruent compared to when these are congruent. These effects can be modulated by such variables as local-shape spacing, and the size and meaningfulness of the shapes [1,2,4].

Given their potential to separate global from local processing, it is not surprising that Navon stimuli have also been used in neuropsychological studies of patients with brain lesions [5] and in functional imaging studies in 'normal' human populations [6]. These studies have suggested that the right hemisphere performs a predominantly global processing of the stimulus, while the left hemisphere performs primarily local processing. Interestingly, recent reports suggest there are inter-individual differences in the processing of Navon stimuli, with the variation showing a linkage to psychiatric syndromes such as schizophrenia [7], autism [8] and obsessive-compulsive disorder [9]. An understanding of the neural mechanisms involved in processing of hierarchical stimuli is thus not just of academic interest but may also have clinical relevance.

Despite the sizable literature on the processing of hierarchical stimuli and the global-precedence effect, its neural underpinnings are still poorly understood. In particular, it has thus far been unclear how single neurons respond to the global and local shapes; for example, do neurons in the visual cortex respond more strongly or quickly to global than to local shape? Sripati and Olson [10] have recently investigated this issue in macaque inferior temporal (IT) cortex. Macaque IT cortex is a good candidate for studying responses to Navon stimuli, because many IT neurons show shape selectivity [11–13] and can have sufficiently large receptive fields [14] to respond to the global shape as well. Also, previous studies have suggested a link between the shape selectivity of macaque IT neurons and shape perception [15].

Sripati and Olson [10] recorded the spiking activity of single IT neurons to four Navon stimuli (Figure 1). These four combinations of local and global shape allowed the researchers to determine whether IT neurons show a greater and/or faster selectivity for the global component over the local shapes. They found that some IT neurons showed selective responses for the global shape, responding, for instance, with higher firing rates to the global circle compared to the global diamond, irrespective of the shape of the local elements. A partially overlapping set of IT neurons showed selectivity for the local shapes irrespective of the global shape configuration. The incidences of global and local shape selectivities were similar, showing no predilection for global shapes. In fact, the degree of selectivity was less for global than for local shapes, perhaps due to the fragmented nature of the global shape in these stimuli [16]. Importantly, the average global shape selectivity, although weaker, developed about 30 ms earlier than the local shape selectivity. Thus, a population of IT neurons can represent both the local and global shapes of hierarchical displays but the IT representation of the global shape precedes that of the local shape.

Sripati and Olson [10] additionally presented single shapes of the same sizes as the local and global shapes — a single small or large circle or diamond. They found that the selectivity was also faster for the large shapes than for the single small shapes. Furthermore, selectivity for the global shape was correlated with the selectivity for the large shape, and selectivity for local shape was correlated with the selectivity for the single small shape. The difference in large–small response latencies was also correlated with the global–local difference in latency across neurons. These findings suggest that the response differences observed between the global and local shape were due to their differences in size and not to hierarchical level. Bigger is faster: larger trees are discriminated more quickly than smaller trees, and the forest is detected faster because it is larger than its component trees.

Several factors may have contributed to the faster IT selectivity for larger shapes. To match the locations of the single shapes to those of the local and global shapes in the hierarchical stimuli, the small and large shapes were centered at different retinal positions. The possibility cannot be excluded that responses to a peripherally-centered shape shows a longer latency than a centrally-positioned shape. Apart from their differences in size, large and small shapes also differ in spatial frequency content, and resolving features of a small shape requires higher spatial frequencies than does a large shape. Response latencies of primary visual cortical neurons (area V1) are shorter for low than for high spatial frequencies [17], which fits the shorter latency observed for the large-shape selectivity in the IT study. Overall, the earlier emergence of selectivity for large shapes agrees with the proposal [18] that the visual world is first analyzed at a coarse scale before turning to its finer details: first the rough outline of the forest, and then the trees, followed by twigs and leaves.

Macaque monkeys show a global-advantage effect in their behavioral reaction times [19]. Is the earlier-appearing selectivity for larger shapes observed in macaque IT related to the behavioral global-advantage effect? Because the study by Sripati and Olson [10] was performed in animals that were passively fixating during the recordings but were not performing a shape discrimination task, we do not know whether the responses of the IT neurons relate to the perceptual global advantage. This missing link needs to be addressed in future studies.

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Behavioural Ecology: Noise Annoys at Community Level

A new study on the impact of anthropogenic noise on birds takes a behavioural discipline to the level of community ecology: noise can not only harm individual species but also alter species relationships.

Hans Slabbekoorn and Wouter Halfwerk

Anthropogenic noise can be detrimental to many animal species in urbanized areas through stress, disturbance, or masking, but this impact is hard to study independently. As they report in this issue of *Current Biology*, Francis *et al.* [1] have tackled this issue in a new study of avian communities at noisy and relatively silent natural gas extraction sites, avoiding the typical confounding factors associated with highways or cities. The study not only confirmed that anthropogenic noise can have negative effects on breeding density for several species, but also demonstrated positive effects on other species that seem to benefit from a noise-associated decline in their major nest-predator. This impact of noise goes beyond the perils for single species and indicates anthropogenic infiltration at community level.

Elevated noise level through anthropogenic activity is a global phenomenon and probably only hearing-impaired people can say they have never experienced it. It is so common that most of us are habituated to unnaturally high noise levels. Many city-dwellers are even able to enjoy some sort of ‘perceptual quietness’ despite high decibel levels, for example when traffic noise is mixed with the wide-band noise of a city fountain and traffic is visually shielded by vegetation. But when the transmission of an important message depends on acoustics, the appreciation of noisy soundscapes changes dramatically. Just imagine